



IV&V project assessment process validation



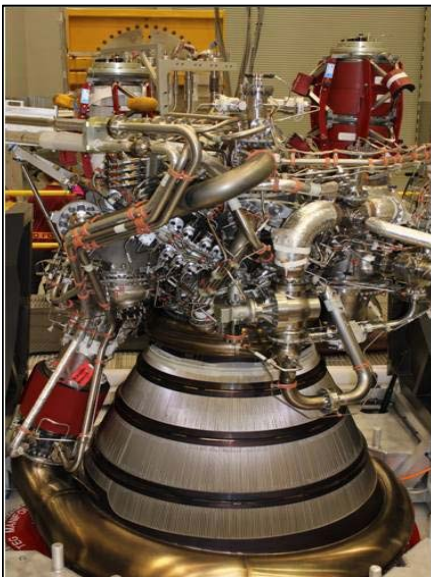
Method: map the Space Launch System
SRR/SDR IV&V findings to

IV&V PBRA

IV&V RBA

IEEE 1012-2004 Scorecard

*Reference: All graphics from
SLS Industry Day



IV&V project assessment Process Validation Presentation

- Presenters
 - Stephen Driskell
 - Team Members for Questions

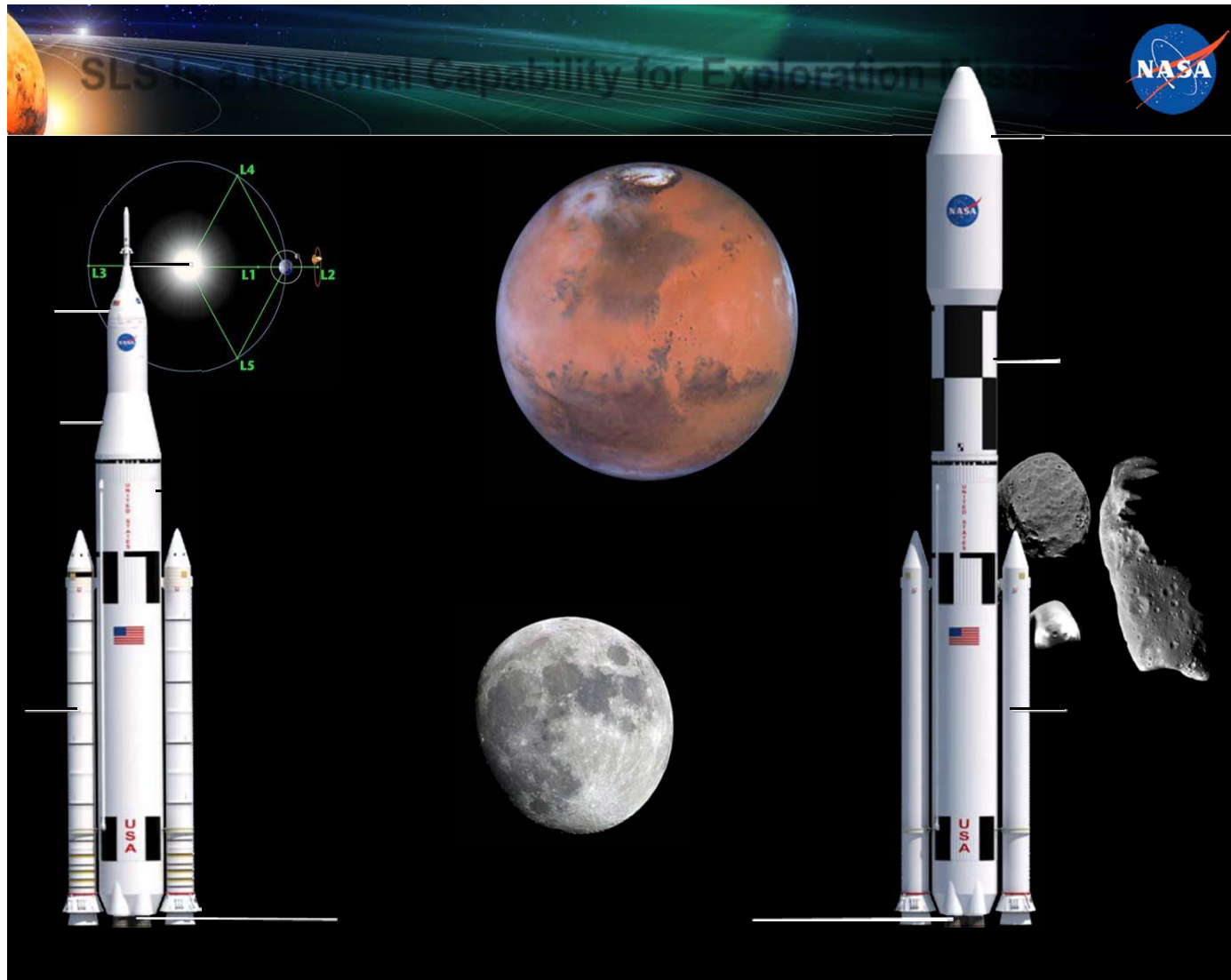
Study support from

- Rich Wolf, HEO ESD IV&V Deputy Project Manager
- Christina Moats, HEO ESD IV&V Project Manger

NASA IV&V SLS Topic & Participants

- **Abstract**: The Space Launch System (SLS) will launch NASA's Multi-Purpose Crew Vehicle (MPCV). This launch vehicle will provide American launch capability for human exploration and travelling beyond Earth orbit. SLS is designed to be flexible for crew or cargo missions. The first test flight is scheduled for December 2017. The SLS SRR/SDR provided insight into the project development life cycle. NASA IV&V ran the standard Risk Based Assessment and Portfolio Based Risk Assessment to identify analysis tasking for the SLS program. This presentation examines the SLS System Requirements Review/ System Definition Review (SRR/SDR), IV&V findings for IV&V process validation correlation to / from the selected IV&V tasking and capabilities. It also provides a reusable IEEE 1012 scorecard for programmatic completeness across the software development life cycle.
- Two teams performed separate concurrent assessments
 - IV&V Participants in the SLS SRR/SDR
 - Melvin Rother, Bimal Patel, Vaughn Harvey, Stephen Driskell, Thomas Marshall, Gary Barber, James Chamberlain, and Noble Nkwocha,
 - IV&V Participants in the RBA and PBRA
 - Van Casdorff, John Bradbury, Rodger Barrington, David Frazier, James Dell, Richard Wolf, and Kimberly Mittelsted,

SLS Missions Summary



Exploration
Missions For
Earth and Moon
to
Asteroids
Mars
& Mars Moons

Initial Capability
70 mt in 2017
to
Evolved
Capability
130 mt
Cargo

SRR/SDR IV&V results

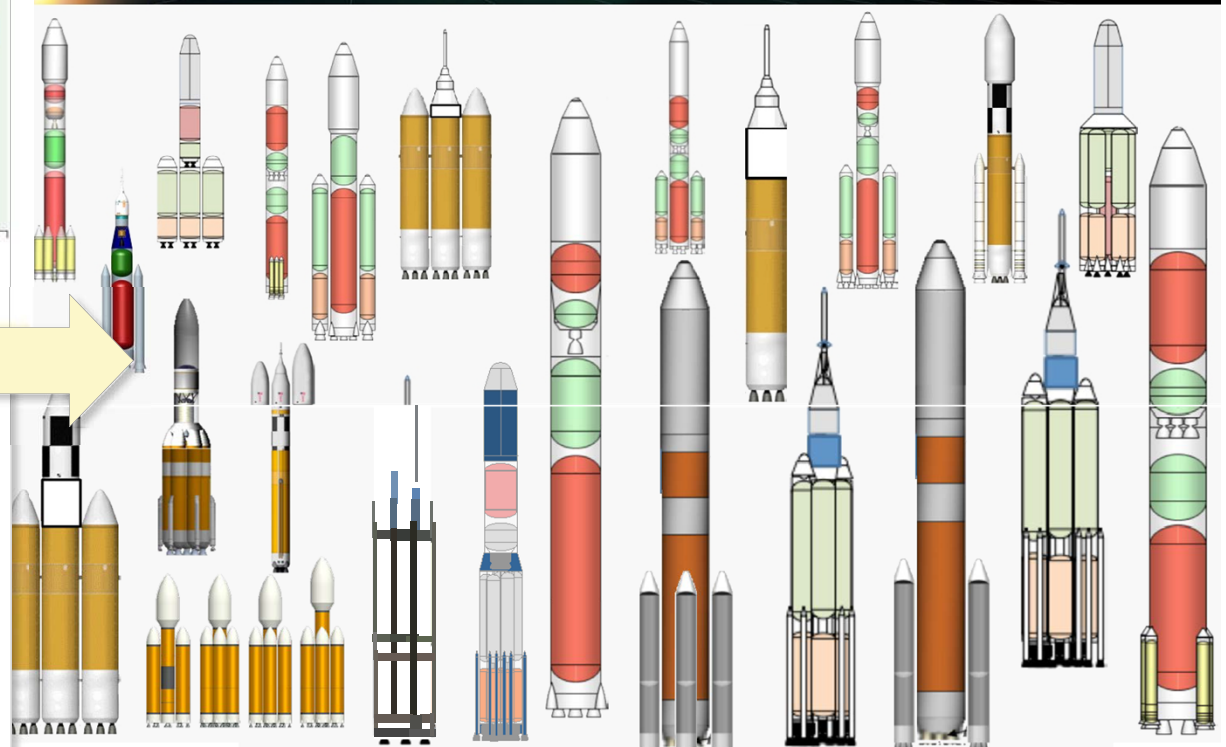
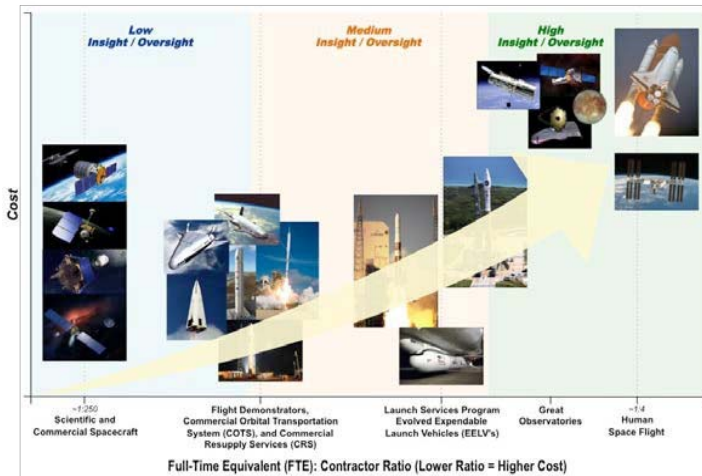
- *IV&V team submitted 33 Pre-RIDs, of which 7 became stand-alone RIDs and 4 were combined into other RIDs. All of the information submitted by the IV&V team (whether on a RID or not) was provided to the SLS personnel in that area to be incorporated into the program*
- *All of these Pre-RIDS and RIDS fall into one of three categories:*
 - *IV&V issues Accepted as RIDS* 7
 - *SLS Program Combined IV&V comments with other reviewers RIDS* 4
 - *SLS Program comments to documents and “future work”* 22

IV&V project assessment validation results

- PBRA - there is a GOOD correlation from SRR/SDR IV&V RIDS and Pre-RIDS to the Portfolio Based Risk Assessment
- RBA - there is a GOOD correlation from SRR/SDR IV&V RIDS and Pre-RIDS to the Risk Based Assessment
- IEEE 1012 - there is a GOOD correlation from SRR/SDR IV&V RIDs and Pre-RIDs to the SRR/SDR Software Life Cycle to the IEEE 1012 Software Validation and Verification Standard - 2004

SLS Affordability Tenets & Options

Boosters, Stages, Engines, Spacecraft & Fairings,
Advanced Development + Existing Capabilities

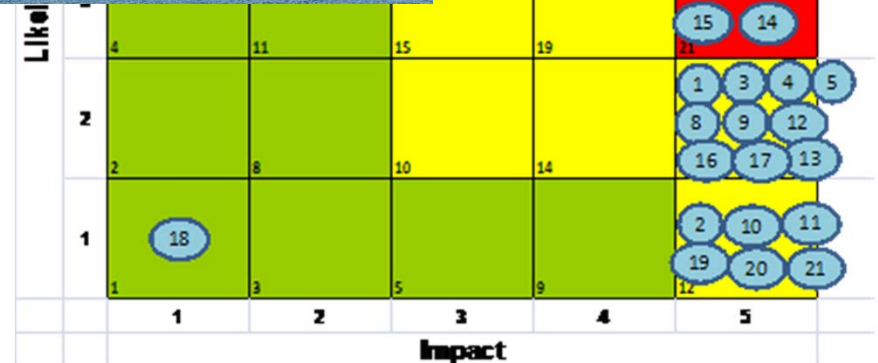


Program/Project Management	Risk-Averse Culture	Requirements/ Trades	Personnel/ Staffing
INSIGHT & OVERSIGHT	Cost as independent variable in design trades	Clear requirements/ Rationale at the right level	Program / Project leadership
Planning for strategy vs. Near-term execution	Understanding implications of safety	Cost as independent variable in design trades	Right people in right roles
Clear and simple lines of accountability	Early identification and resolution of issues	Multiple reviews and approvals	Long-term skill maintenance / development
Business / contractual relationships, methods, and incentives	Delegation of authority	Industry vs. Government standards	Use of in-house capability to support programs
Use of modern technology	Certificate of Flight Readiness process	Cost requirements and estimates	
Smaller projects / Periodic achievable milestones			

Opportunities for Change

PBRA Map to IV&V SRR/SDR Results

ID	RIDs only	Pre-RIDs	Capability
SLS1	1	2	SLS.Provide Health & Status data
SLS2			SLS.Provide Caution & Warning data
SLS3			SLS.Provide Fault Detection
SLS4			SLS.Provide Fault Isolation
SLS5			SLS.Provide Fault Recovery
SLS6	7	8	SLS.Perform Vehicle State & Mode Management
SLS7	1	4	SLS.Perform GNC
SLS8			SLS.Manage Subsystem Power
SLS9		1	SLS.Manage Flight Termination System
SLS10		5	SLS.Perform Required Abort Sequence
SLS11			SLS.Control Boosters
SLS12			SLS.Control RS-25 Engines
SLS13		2	SLS.Control iCPS Engine
SLS14		2	SLS.Control CPS Engine
SLS15	1	4	SLS.Control J-2X Engines
SLS16	1	3	SLS.Track Ascent Operations
SLS17			SLS.Provide CMD Validation & Acceptance
SLS18			SLS.Provide onboard command history
SLS19		1	SLS.Provide Data to Ground
SLS20		1	SLS.Provide Data to MPCV
SLS21			SLS.Provide stage break-up and sinking upon impact
Total	11	33	



RBA To IV&V SRR/SDR

SLS RBA 5x5 Results					
5	7	16	20	23	25
4	6	13	18	22	24
3	4	11	15	19	1
2	2	8	10	14	2
1	8	14	19	5	9
	1	2	3	4	5
Impact					

ID	RIDS only	Pre-RIDS ***	Entity
1		3	Guidance, Navigation & Control
2		1	Thrust Vector Control
3		2	Real Time Operating System
4			Hardware I/O
5	2	4	M&FM - Mission Manager
6		4	M&FM - Abort Manager
7			M&FM - Flight Computer Redundancy Manager
8			Special Test Application Software
9			CTC Application Software
10			Development Flight Instrumentation
11		N	Redundant Inertial Navigation Unit
12			Camera Controller Unit / Imaging System
13			Core Stage Power Distribution & Control Unit
14	1	1	Data Acquisition Control Unit
15		1	Core Stage Engine Control Unit
16			Rate Gyro Assembly
17	1	4	Flight Safety System
18		1	Data Acquisition & Recording Unit
19			Engine Data Acquisition Unit
20		N	DOLILU
21	4	4	Flight Design
22	3	5	Mission Execution & Flight Ops
23		2	Upper Stage Engine Control Unit
24		1	1553 I/O
Total	11	33	

N – Not evaluated in SRR/SDR

IV&V SLS Results MAP to IEEE 1012-2004

- SRR/SDR IV&V findings
- Mostly Requirements
- Some Findings on
 - Architecture
 - Verification
 - CONOPS



IEEE 1012-2004 Standard for Software Verification and Validation	SLS Artif act #1	SLS Artif act #2	SLS Artif act #3	IV&V Pre- Rid & RID	References
1. Overview					
2. Referenced documents					
3. Definitions					
4. Software integrity levels					
5. Software V&V processes					
5.1 Process: Management					
5.1.1 Activity: Management of V&V					
5.2 Process: Acquisition					
5.2.1 Activity: Acquisition support V&V					
5.3 Process: Supply					
5.3.1 Activity: Planning V&V				1	V&V plan, testing & risk criteria not defined
5.4 Process: Development				1	SDR/SRR artifact maturity
5.4.1 Activity: Concept V&V				1	CONOPS - Engines & Stages 1001
5.4.2 Activity: Requirements V&V				26	Requirements
5.4.3 Activity: Design V&V				1	upper stage sensor missing
5.4.4 Activity: Implementation V&V					
5.4.5 Activity: Test V&V				1	Vehicle Management Spec: missing verification, clarify role
5.4.6 Act: Installation and checkout V&V					
5.5 Process: Operation					
5.5.1 Activity: Operation V&V					
5.6 Process: Maintenance					
5.6.1 Activity: Maintenance V&V					
6. Software reporting requirements					
6.1 V&V reports					
6.2 V&V administrative requirements					
6.3 Documentation requirements				1	Architecture
7. Software V&V plan outline				1	Verification Activities
Annex A Mapping tables					
Annex B risk based integrity level scheme					
Annex C IV&V types					
Annex D V&V of reuse SW					
Annex E V&V measures					
Annex F Organizational relationship					
Annex G Optional V&V tasks					
Algorithm analysis.					
Regression analysis and testing.					
Reuse analysis.					
Simulation analysis.					
Sizing and timing analysis.					
Total				33	

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WRAP UP

- NASA IV&V Process for RBA and PBRA supports the capabilities for selecting analysis targets to support SMA and national objectives for the

SLS Innovative New Business Model

- Based on the SRR/SDR Findings IV&V will revisit the PBRA/RBA rationale for
 - Perform Required Abort Sequence
 - Track Ascent Operations
 - Flight Safety System
 - Provide Health and Status Data
- Study shows good validation for the PBRA and RBA priorities established by the NASA IV&V IPEP process
- Study shows good validation for the SLS NASA life cycle activity with accepted RIDS on Launch Vehicle (LV):
 - Launch Vehicle to SW Functional Allocations Missing
 - Safety Critical SW not identified
 - V&V Testing and Risk Criteria not complete

